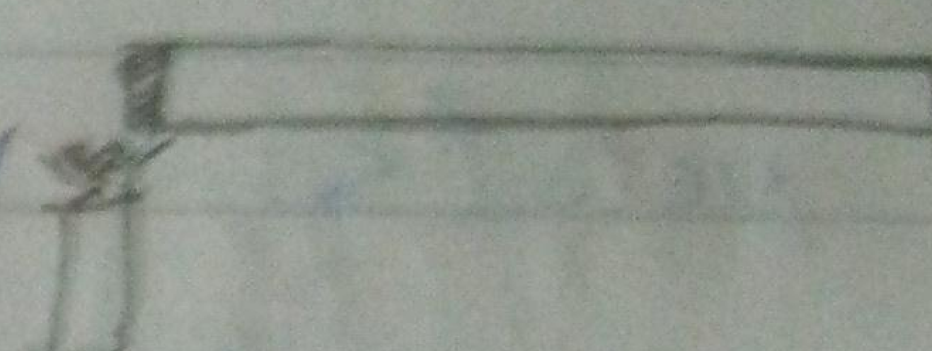
Heat and optics

Heat ① Heat Transfer.
② Kinetic theory of gases.
③ 1st law of thermodynamics

Heat Transfer

→ 3 ways to transfer heat
1) conduction.
2) convection.
3) radiation → Vacuum.

→ Heat Transfer ~~with~~out and molecules don't Transfer



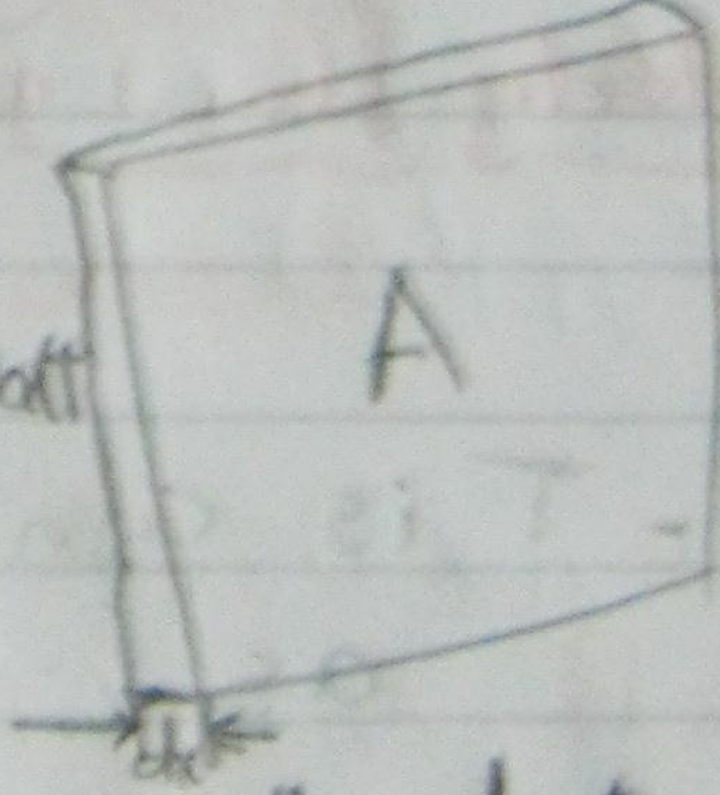
In metals free electrons + molecules.

Thermal conductivity

. Heat current: The amount of heat ~~that~~ across the section of this material in one second.

$H = Q/t$, $H = \frac{Q}{t} \propto A$,

$H = \frac{Q}{t} \propto \frac{dT}{dx}$ J/sec = watt



$\frac{dT}{dx}$ = Temp gradient.
(gradient is any change with distance).

→ Thermal conductivity coefficient $H = \frac{Q}{t} = KA(-\frac{dT}{dx})$.
The amount of heat per unit Time flowing normal to the face of unit area of the material to cause unit Temp. gradient.

$K = \frac{H}{A\left(-\frac{dT}{dx}\right)}$. (coefficient).

$[H]$ = watt. $[K] = \frac{\text{watt}}{m^2 \cdot \frac{°K}{m}}$ = watt / m°K.

1 Calorie = 4.186 Joule.

$\boxed{[K] = Cal\ s^{-1}\ cm^{-1}\ K^{-1}}$ ⟹ lap.

· Good Conductors

metals: Cu, Ag, Al.

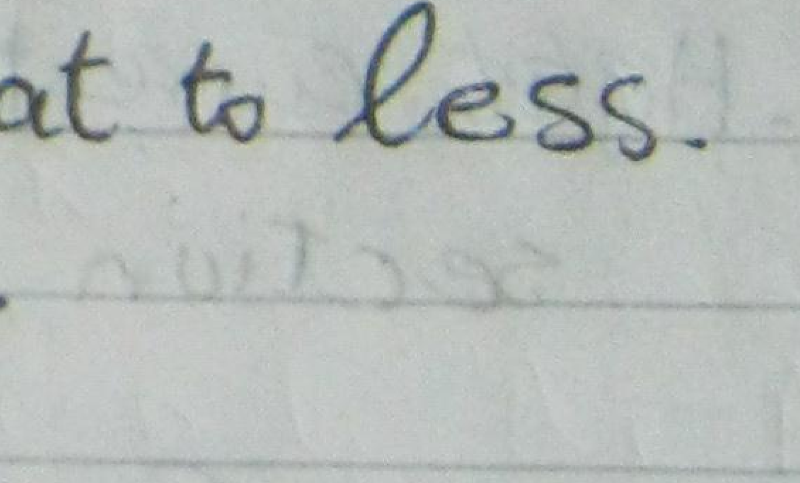
· Bad Conductors

metals: wood, wool, glass, ebonite.

$\boxed{\text{Note}}$ heat Transfer from greater heat to less.
as (from hand to keys).

Stedy flow of heat T : Const with time.
T = may vary with position.

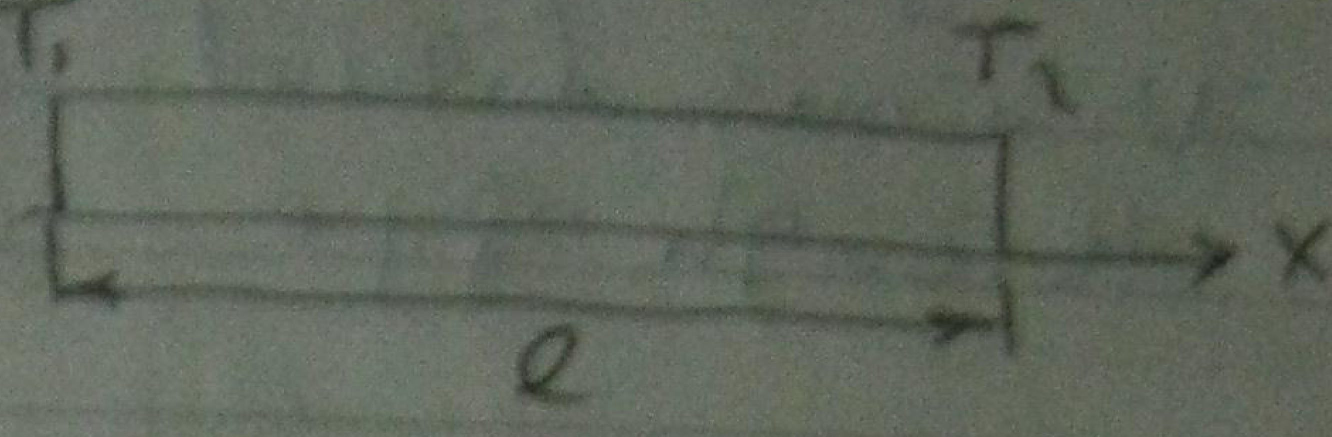
- T is const in a given position
as (· or x)



- Ti is vary ~~from~~ among (·, x, △/□)

the uniform bar

$$H = \frac{Q}{t} = -KA\frac{dT}{dx}$$



$$\boxed{\int_{T_1}^{T} dT = -\frac{H}{KA}\int_0^x dx}$$

$$T - T_1 = -\frac{H}{KA}x \qquad \therefore \boxed{T = T_1 - \left(\frac{H}{KA}\right)x} \Rightarrow (1)$$

$$\int_{T_1}^{T_2} dT = -\frac{H}{KA}\int_0^{\ell} dx \qquad \boxed{H = \frac{KA}{\ell}(T_2 - T_1)} \Rightarrow (3)$$

$$\boxed{T_1 - T_2 = \frac{-H}{KA}\ell} \Rightarrow \text{Relation between } T_1 \text{ and } T_2 \quad (2)$$

By (1) and (2) $\boxed{\frac{H}{KA} = \frac{T_1 - T_2}{\ell}} \Rightarrow (4)$

By (1) and (4) $\boxed{T = T_1 - \left(\frac{T_1 - T_2}{\ell}\right)x}$

By (1) $H = \frac{Q}{t} = \frac{T_1 - T_2}{\ell / KA} \Rightarrow$ as ohm's law

$i = \frac{Q}{t}$; Q = amount of charge
t = Time.
i = electric current.

$$i = \frac{V_1 - V_2}{R}$$

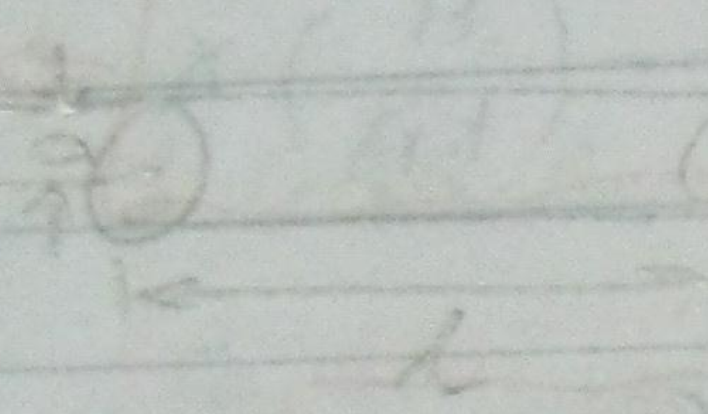
$H = \frac{Q}{t}$; Q = amount of heat
t = Time
H = heat current

$$H = \frac{T_1 - T_2}{\ell / KA}$$

$$R = \rho \frac{\ell}{A}$$

stedy flow of viscous liquid through a pipe

$$Q = \frac{\Delta P \pi a^4}{8 \eta l} = \frac{Vol.}{Time}$$



$$Q = \frac{Volume}{Time} = \frac{\Delta P \pi a^4}{8\pi \eta \left(\frac{l}{\pi a^2}\right)}$$

$$Q = \frac{Force}{8\pi \eta \left(\frac{l}{A}\right)}$$

⇒ Force causing the motion

→ $8\pi\eta$: viscous Resistivity

⇒ $8\pi\eta \frac{l}{A}$: viscous Resistance

steady flow of Heat

$$H = \frac{Q}{t} = \frac{T_1 - T_2}{l/KA}$$

⇒ $\frac{l}{KA}$: Thermal resistance

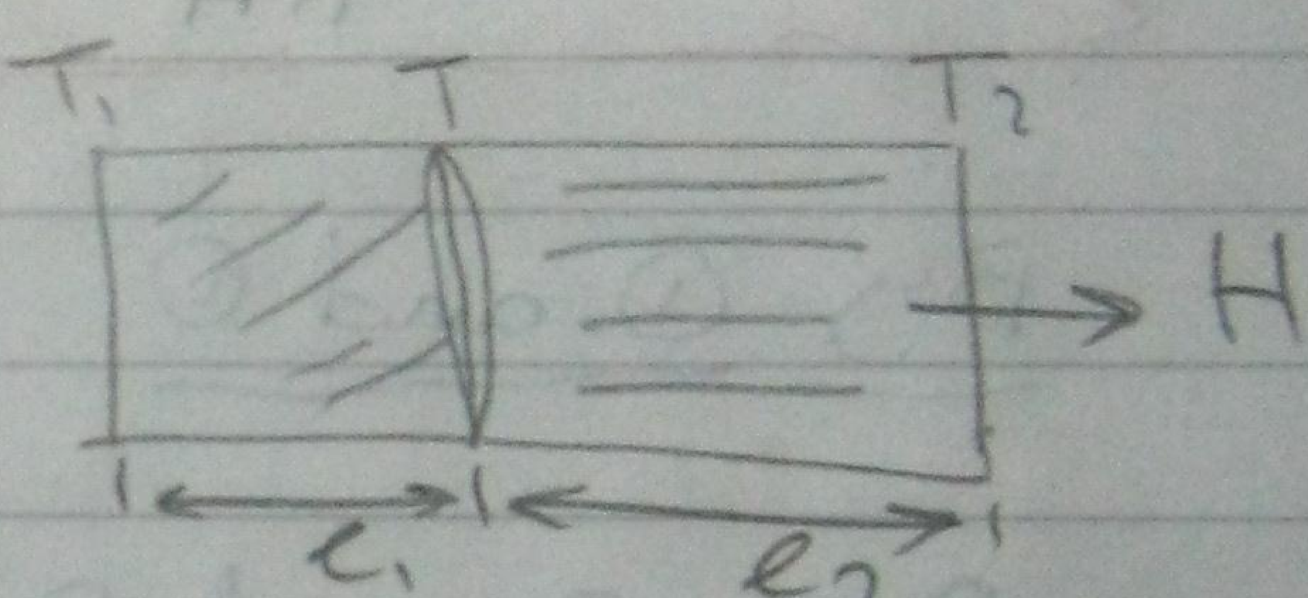
steady flow of charge

$$i = \frac{Q}{t} = \frac{V_1 - V_2}{R}$$

$$R = \frac{l}{\sigma A}$$

$$R = \rho \frac{l}{A}$$

⇒ Compound wall



$$H = \frac{T_1 - T}{R_1} \quad (1) ; \quad R_1 = \frac{l_1}{k_1 A}$$

$$H = \frac{T - T_2}{R_2} \quad (2) : \quad R_2 = \frac{l_2}{k_2 A}$$

$H \Rightarrow$ Const $A_1 = A_2$

$(T_1 > T > T_2)$

$$\boxed{T = \frac{R_1 T_2 + R_2 T_1}{R_1 + R_2}}$$

By (1), (2)

$HR_1 = T_1 - T$, $HR_2 = T - T_2$

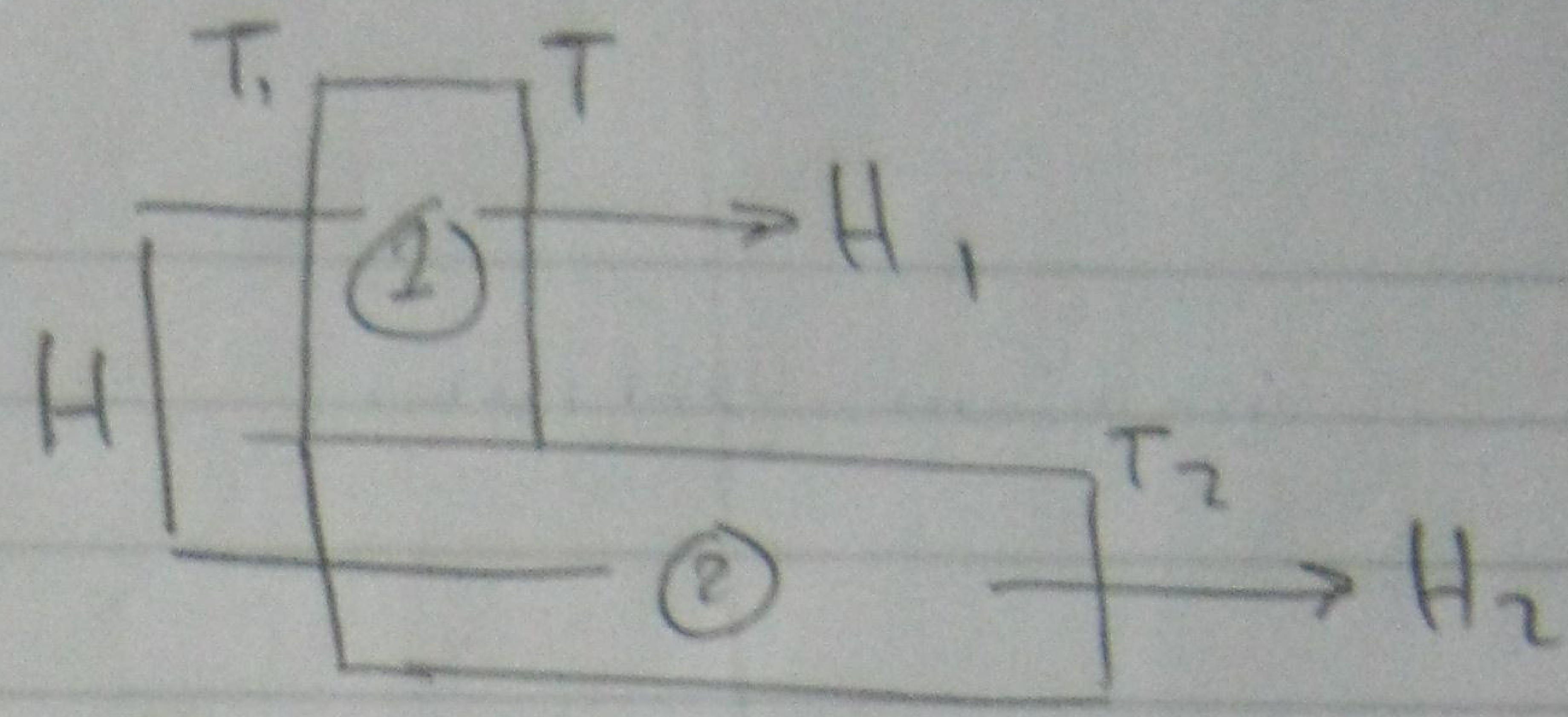
by addition

$H(R_1 + R_2) = T_1 - T_2$

$$H = \frac{T_1 - T_2}{R_1 + R_2} = \frac{T_1 - T_2}{R}$$

$R = R_1 + R_2$ ⇒ series connection.

② Common edge



$$H = H_1 + H_2.$$

(1) - $H_1 = \frac{T_1 T_2}{R_1}$, $H_2 = \frac{T_1 - T_2}{R_2}$ - (2)

addition of (1+2) $H = H_1 + H_2 = T_1 - T_2 \left(\frac{1}{R_1} + \frac{1}{R_2}\right)$

$$H = \frac{T_1 - T_2}{R}$$

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ (Parallel connection).